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The Somma-Vesuvius Activity with a Focus to the AD 79 Eruption: Hazard and Risk

Angelo Paone

Abstract

Somma-Vesuvius is a quiescent stratovolcano with a probability of Plinian style volcanic reactivation. Its stratigraphy is well known in the last 40 ka BP. The volcanic products that are part of the Somma caldera are poorly studied. Conversely, younger products have been deeply studied together with the AD 79 Plinian eruption. The impact of a Plinian eruption has been studied and summarised here. A simplified scheme is presented from what we can understand the volcanic hazard and risk that the volcano poses to the greater Neapolitan population. In the last 40 years, the demography around the Somma-Vesuvius volcano has increased; consequently, the volcanic risk has increased. It would seem that the Italian Civil Protection (ICP) has not influenced the population and the Italian authority with their massive work around Somma-Vesuvius (red zone). People still continue to build houses. Nowadays, the Somma-Vesuvius volcano does not seem to threaten people or the people that live around Vesuvius are not afraid of the volcano. But as it is usual just in this moment that the work done and to be done must be speared to all Neapolitan people, working in the school to reach the family. People around Somma-Vesuvius tend to neglect the volcanic risk appearing around Vesuvio. So ICP, all must be much more attend about the behaviour of this Hazardous volcano.

Keywords: Somma-Vesuvius, AD 79 eruption, Plinian, Hazard, Pompeii

1. Introduction

Somma-Vesuvius volcano has shaded many volcanological avenues since the two letters of Pliny the Younger to Tacitus [1]. He described the dynamism of the Pompeii Plinian eruption. Since then, Somma-Vesuvius has utterly been studied by many earth scientists worldwide who have increased the knowledge of the volcano. Today, Somma-Vesuvius is the best studied and monitored volcano in the world. The volcano is very much known about its volcano stratigraphy and by the chemistry of the volcanic products as well as by the physical architecture of the volcano. Anyhow, it is little known how the population feel about the impact of the hazardous volcanic eruptions [2–6]. To envisage different volcanic scenarios is a must in order to help the population around Vesuvius to better understand the type of next eruption that will impact on the region nearby Somma-Vesuvius. A simplified scheme of AD 79 eruption related to all the volcanic activity of a such destructive volcano can shed

light and ease the Neapolitan population that live around Somma-Vesuvius in case of future Plinian eruption. This simplified review on an open access international journal can also be available for students and general population and help high school students to understand the hazard of Somma-Vesuvius and to discuss this issue with their family.

2. Short notes on the stratigraphy of Somma-Vesuvius in the last 40 ka BP

The volcanic stratigraphy has been studied in detail in the last 40 ka BP [7]. Before this age, the volcano was looking like the Fuji volcano in Japan today (**Figure 1**). This analogy can be a best guess of the Somma volcano before 40 ka BP. The eruptive history of Somma volcano can be studied only on the Somma Caldera wall, which is poorly studied. Today, the volcano called Somma-Vesuvius volcano looks like the one shown in **Figure 2**. The aerial photo shows clearly the two morphologic characteristics: Somma caldera and Vesuvius cone nested into the



Figure 1.
Fujiyama volcano, Japan (taken from the Web).



Figure 2.
Aerial photo of Somma-Vesuvius (Somma caldera e Vesuvius cone).

caldera. The Somma caldera is well exposed and looking from the North side (from Pollena town); the Vesuvius nested cone is hidden (**Figure 3**). Somma volcano should have been around 2000–2500 m high extrapolating from Somma Caldera, much higher than actual altitude of Vesuvius cone (Rolandi, unpublished data) [8]. The analysis of the eruptive history of Somma-Vesuvius (**Figure 4**) reveals the recurrence of highly explosive events followed by repose periods, during some of which low (2-3-4) VEI strombolian and/or vulcanian style eruptions took place [9]. The last eruptive cycle at Vesuvius lasted from 1631 to 1944 [9]. The AD 1944 eruption is the last eruption of Vesuvius Cone. Now, the volcano is in a repose period, which can be followed by a Plinian eruption. The behavior of Vesuvius volcano in the last 3800 years BP can be seen in **Figure 5** [9]. After the famous Avellino



Figure 3.
Somma caldera seen from North to West.

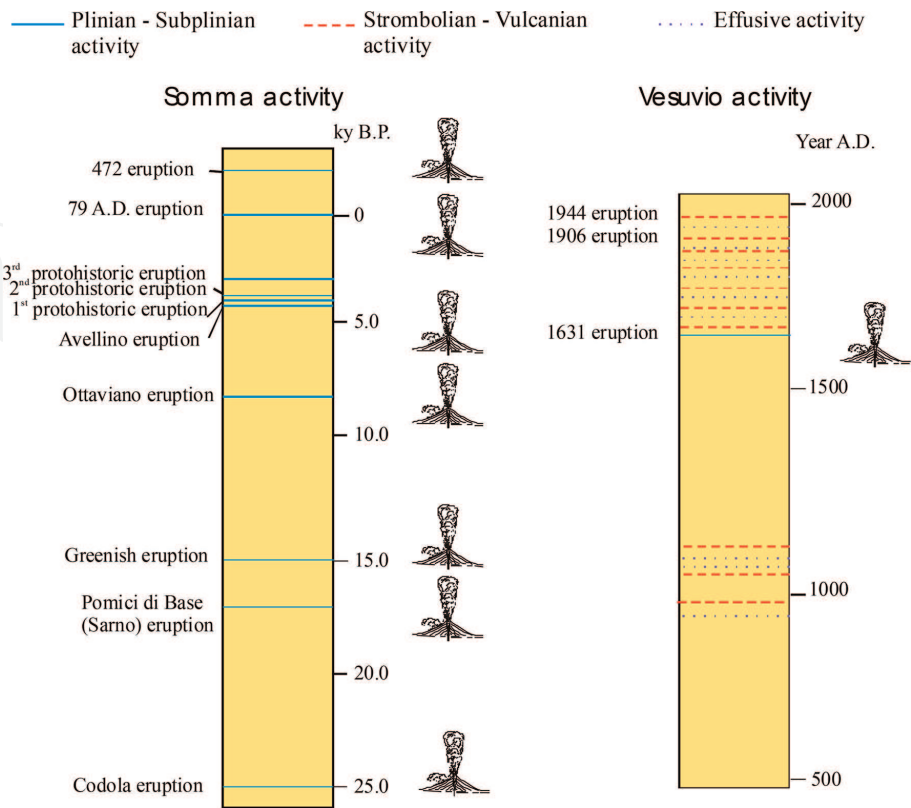


Figure 4.
Somma-Vesuvius stratigraphic sketch with Somma activity and Vesuvius activity with style of eruption.

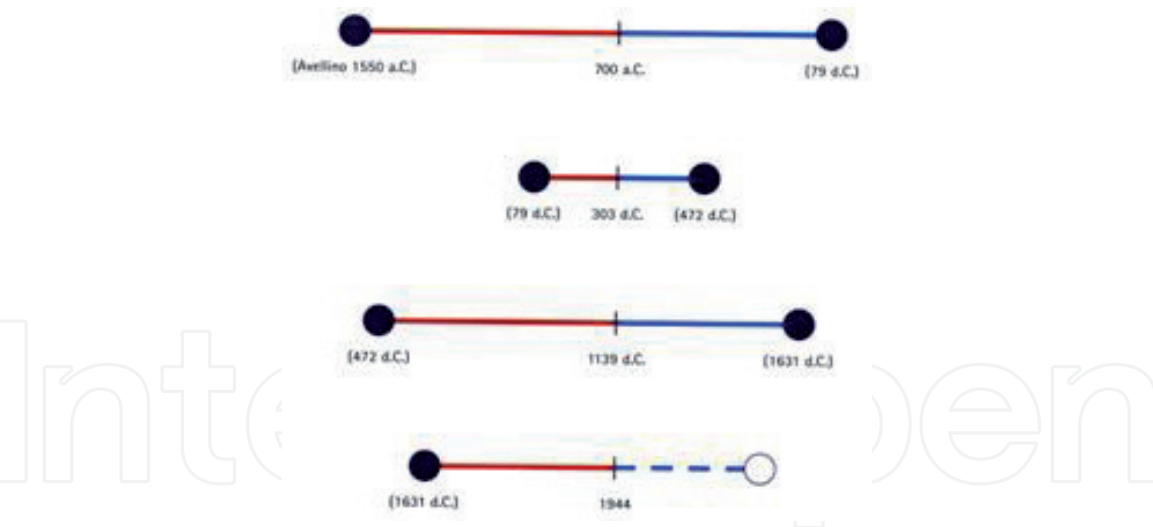


Figure 5. Activity of Somma-Vesuvius from Avellino eruption to the 1944 eruption: Plinian, interplinian and repose time [9]. The interplinian is defined as volcanic cyclic period less explosive after each Plinian eruption.

prehistoric Plinian eruption, the Somma changed its eruption behavior, and the sequence of Plinian-interplinian-repose time took place until 1944. The protohistoric interplinian phase was followed by 700 years of repose time before the AD 79 eruption (Figures 4 and 5) [9]. According to this sequence, the next eruption at Vesuvius would be of the Plinian style. The Vesuvius matter would be to guess the size of the next Plinian eruption: Avellino-like, AD 79 eruption-like, Pollena-like, and 1631 eruption-like. This is still matter of study if the future eruption will be Subplinian, Plinian, or Ultraplinian.

3. Somma volcano before the AD 79 eruption

Somma volcano, *Vesuvio* for Roman people, before the AD 79 eruption, raised no worry to people living in the volcanic area. The wall painting found in the archaeological excavation of Pompeii depicts the volcano as a one-peaked mountain (Figure 6). Bacco indicates the pleasant life of the time and the fertility of soils. No reference is made to the presence of phenomena (e.g., fumaroles) typical of an active volcanic area. Even in Latin literature (Virgilio, Seneca, Pliny the elder, Columella), the volcano is known only for fertility of its soils. Vitruvius is the only writer to put forward the hypothesis that in the past, although all his contemporaries had forgotten the fact, the volcano had been devastated by powerful eruptions (Figure 6). The Greeks wrote of the age, on the contrary, as Diodoro Siculo (80–20 BC) and the geographer Strabo (1st century BC–AD 19) describe morphological features of Vesuvio volcano: *...flat, without vegetation, similar to ash in appearance, with porous holes in the rocks which are black in colour as if they had been burnt... This is probably why the soils are so fertile ... like Catania... covered by the eruptive ashes from Etna's fire...* (Strabo) (Figure 7). Even seismic activity was not taken into account as a precursor of an eruption, but it was more simply linked to seismogenetic activity of the Apennine Chain. Seneca, in *Quaestiones Naturales*, does not quote Vesuvio when he describes the Pompeii earthquake on February 5 AD 62. The author, not aware of the seismogenesis of volcanic areas, does not recognize this earthquake as a possible precursor of a volcanic event (Figure 8). In [8, 10], it is shown how the evolution of the Somma caldera has been very complex with only the post activity of AD 472 called interplinian started with the growth of Vesuvius cone [9].



Figure 6.
Drawing of Somma volcano during the AD 79 eruption (note a one peaked volcano conversely to the actual two-peaked volcano). Artist unknown found in one Pompei room.



Figure 7.
Drawing of Somma volcano after the Codola eruption and probably Sarno eruption.



Figure 8.
Roman marble sculpture witnessing the earthquake of the AD 62.

4. Date of the AD 79 eruption

The south-easterly trend of the AD 79 products appears to be anomalous, because the eruption is conventionally believed to have occurred on August 24, when its southeast dispersive trend falls in a transitional period from the summer to autumnal wind regimes [11]. In fact, the AD 79 tephra dispersive direction toward the southeast is not in agreement with the June–August high-altitude wind directions in the region that are rather toward the west. This poses serious doubt about the date of the eruption and the mismatch raises the hypothesis that the eruption occurred in the Autumnal climatic period (October), when high-altitude winds were also blowing toward the southeast. New archaeological findings presented in the [11] study definitively place the date of eruption in the Autumn (October), in good agreement with the prevailing high-altitude wind directions above Somma-Vesuvius ([11]; references therein).

5. The chronology of AD 79 eruption: How the eruption impacted on the Roman population

Pliny the Younger observed the eruptive column from Miseno at about 13 h of the day of October 24 (**Figure 9**) [1, 11]. Probably, the start of the AD 79 Pompeii eruption (**Figure 10**) and the eruptive column begin to rise probably at 12 h of October 24 and appear just as strange phenomena for the Pompeii people (**Figure 11**). Fall-out products from the AD 79 eruption can be found both in the surrounding area and at a distance, stretching in a SE direction as far as Cilento: October 24 (the first day of eruption): “...a cloud appeared of unusual size and shape... The cloud advanced in height; and I cannot give you a more just representation than the form of a pine tree...” [1]. Eruptive column of the white pumice was sustained for about 8 h. Pliny the Younger, in its letters to the historian Tacito,



Figure 9.
The younger Pliny reproved.

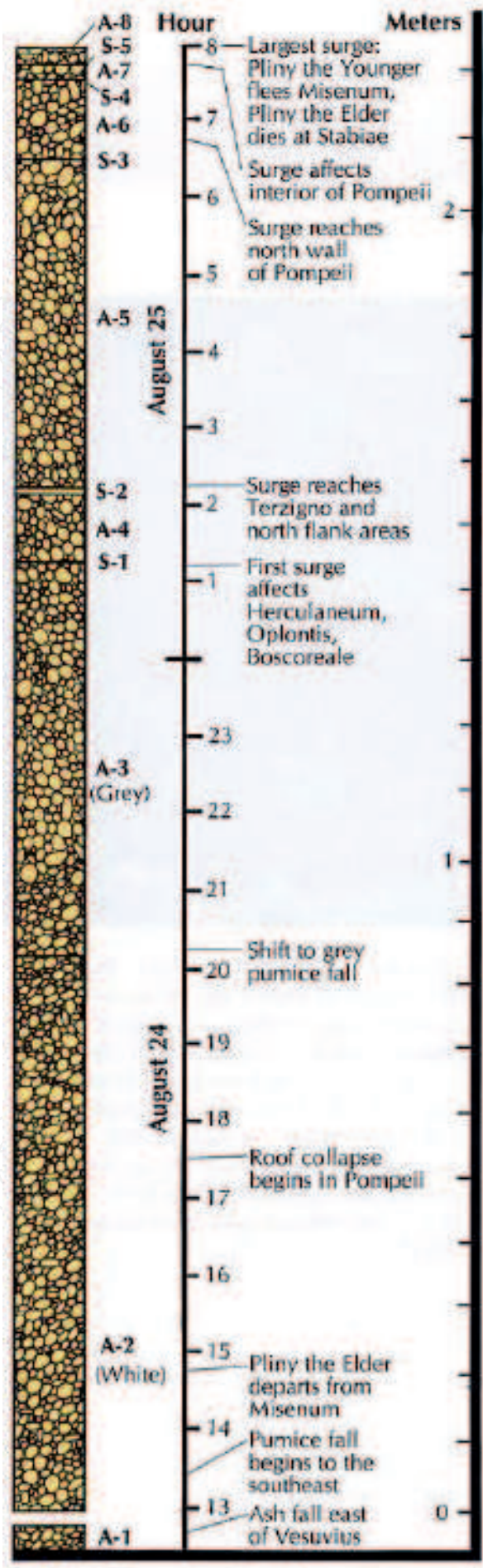


Figure 10.
Modified volcanic section of the AD 79 [20].



Figure 11.
Cartoon shows how the Romans were surprised at the begin of the AD 79 eruption. They were unaware of the volcanic hazard.

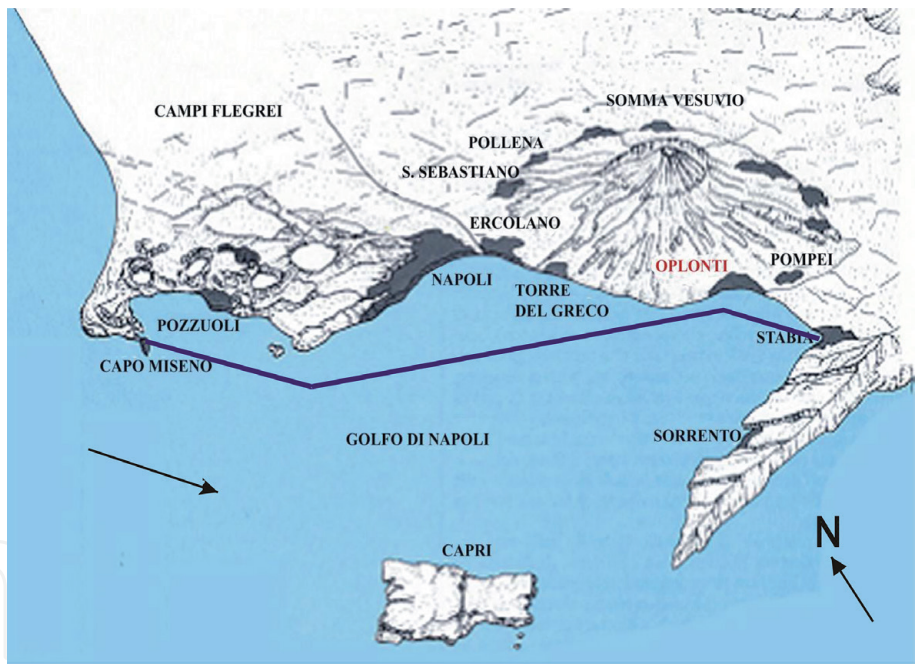


Figure 12.
The route of Pliny the Elder; after that, he realized the start of Somma activity (AD 79 eruption).

writes that his uncle Pliny the Elder “... was at Misenum where he had the command of a fleet which was stationed there. At about 15 h Pliny the elder received a request of help by his friend Rectina and decided to start from Misenum with four Liburnae. After 4 h, he arrived near the coast of Oplonti but he cannot disembark because the effects of the eruption and decided to move toward Stabia, where his friend Pomponiano was located (**Figure 12**). At Pompeii, roof collapse due to the weight of the white pumice level begins between 17 and 18 h (**Figure 13**). After that, the Pompeii eruption changed from white pumice to grey pumice. This transition also changed the composition of the eruption (**Figure 14**). During the first day of the eruption Herculaneum was spared by pumice fall phase and people could observe the pyroclastic cloud diverted toward SE by winds. From about 1 to 8 h of



Figure 13.
Cartoon shows the moment when Pompeii home start to collapse by the load of fall-out volcanic phase.



Figure 14.
Classic section of the AD 79 eruption with white and grey pumice fall-out.

October 25, the Plinian column of grey pumice assumed a collapsing character giving rise to surge and pyroclastic flows currents. Pliny the younger wrote I believe, while the vapor was fresh, it (the cloud) more easily ascended; but when the vapor

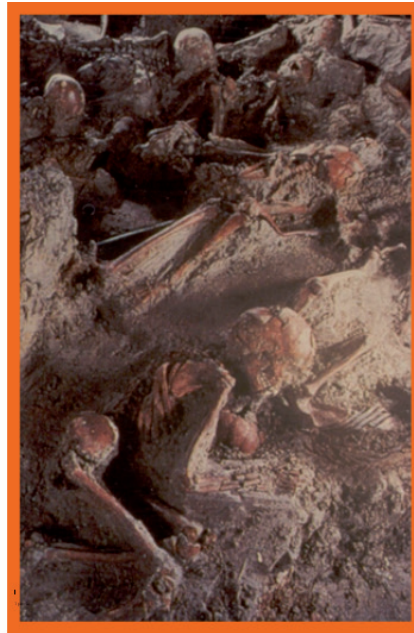


Figure 15.
Herculaneum with Roman community hit by pyroclastic density currents at the end of white and white and grey pumice fall-out.

was wasted the cloud became loose, or, perhaps, oppressed by its own gravity, and dilated itself into a greater breath...”

October 25 (the second day of eruption): pyroclastic flows bury the town (Herculaneum) under a 15-m-thick ash deposit. The inhabitants, in the vain attempt to escape by boat, take refuge in the barrel-vaults along the seaside where they will die (**Figure 15**). The Pompeii and Herculaneum towns, before the eruption, nearly looked out directly over the sea. The AD 79 eruption was a natural event that strongly affected the perivolcanic area of Somma-Vesuvio. The paleogeographic and socioeconomic variations that it caused were huge. After the eruption, the area was completely buried with the consequent progradation of the coast line [12]. Trading in the Nola and Acerra areas was badly affected as communication routes to the sea through the port of Pompeii no longer existed. Toward Stabia, the Pomponiano house was highly damaged by white and grey pumice fall, and the courtyard was filled by pumice deposits, so that early in morning of October 25, Pliny the elder decided to move toward the beach. In the meantime, a phase of eruptive calm had been registered and, in the Pompeii area, people who had managed to escape the



Figure 16.
Cartoon shows how the PDC were severe by hitting Roman villages.

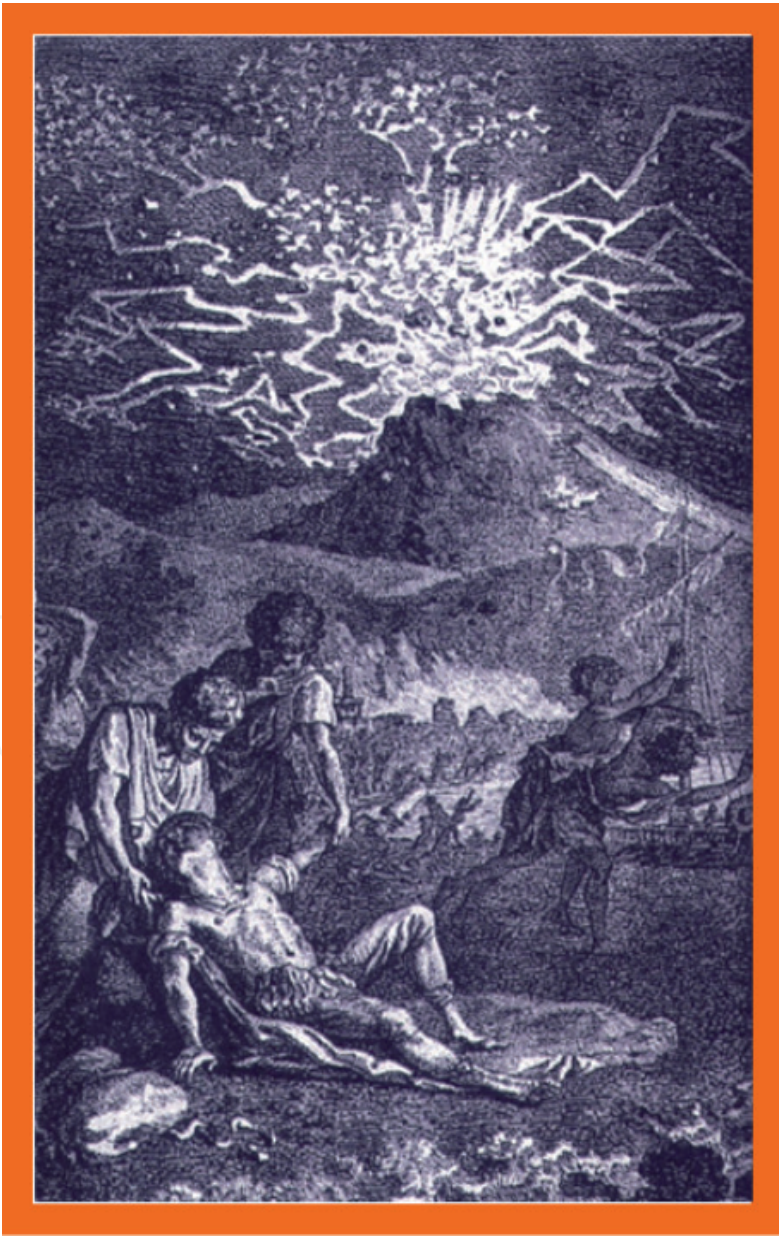


Figure 17.
Engraving showing Pliny the Elder found death on the beach of Stabie village.

effects of the pumice fall phase tried to return to their homes by walking over the pumice deposits which had become as high as the rooftops. As they made their way home, accompanied by some soldiers, hot toxic cloud swamps departed by the hot avalanche that are invading Herculaneum, and kills them (**Figures 16 and 17**).

October 26 (the day after the eruption): Pliny the Elder’s body was found dead on the beach “...when the light returned, which was not till the third day after his death, his body was found untouched by the fire, without any visible hurt, in the dress in which he fell, appearing rather like a person sleeping than like one who was dead” (Pliny’s letters).

The destructive action of pyroclastic products on constructions is exerted in two main ways. Fall products, which are emplaced grain by grain, falling down from the eruptive cloud, blanket roofs with a layer of granular deposit, whose thickness is a function of both the intensity of the eruption and the distance from the vent. The pyroclastic fall layer loads the roofs with an extra weight that, when the maximum sustainable load threshold value is exceeded, can cause the roof to collapse. Pyroclastic density currents (PDC), on the other hand, generally originating from the collapse of the eruptive column, are gas clouds rich in both lithic and juvenile fragments that, running over the ground, exert a dynamic overpressure on the obstacles encountered on their way and are capable to destroy the buildings (**Figure 18**) [13]. Actually, the first damage was made by white pumice fall deposits,

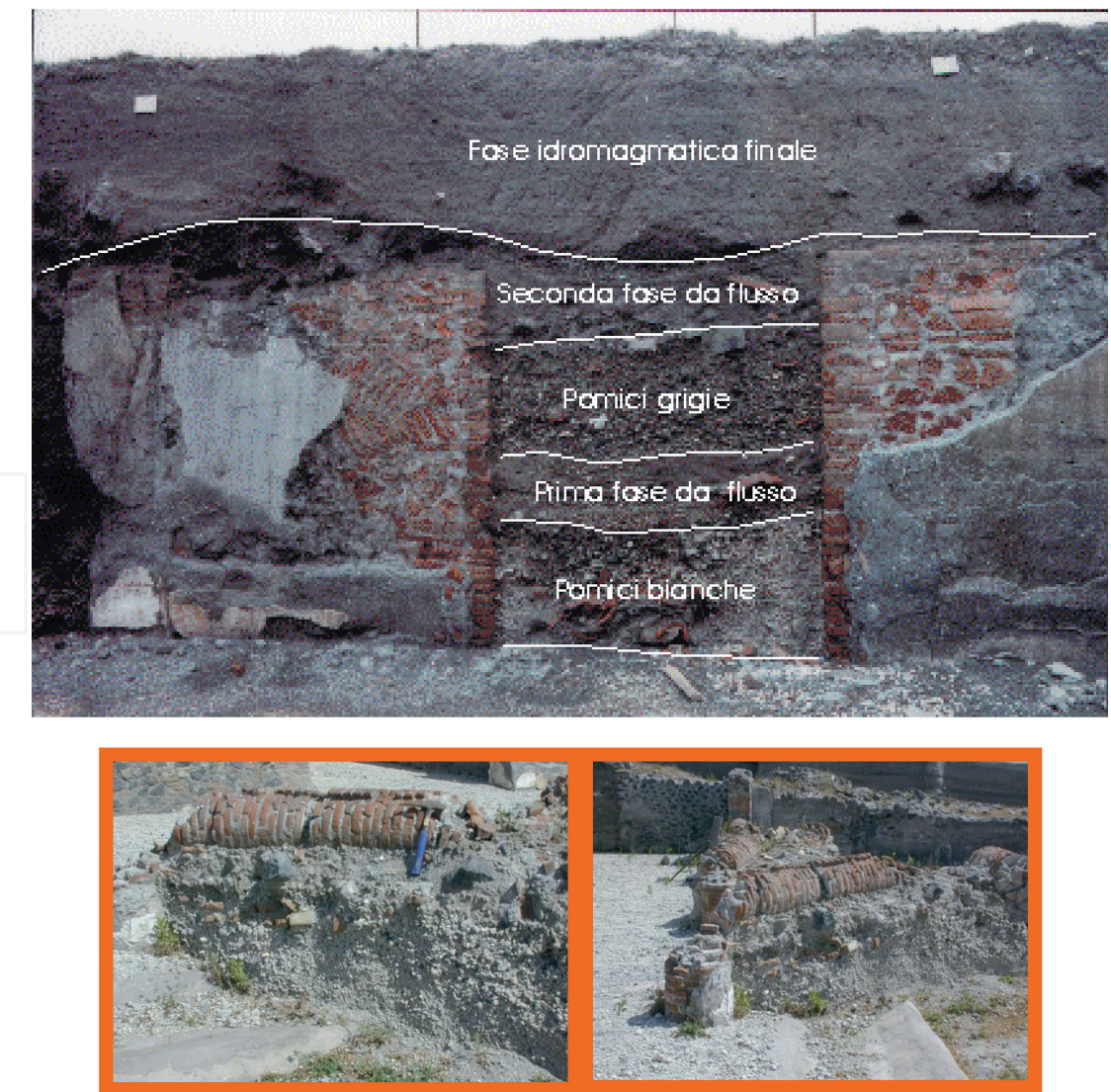


Figure 18.
Effects of AD 79 eruption on Roman buildings: Villa 6 at Terzigno.



Figure 19.
Romans' body-mould made by gypsum in modern age.

weighing on the roofs, leading to collapse them. The first pyroclastic density currents occurred during the late deposition of white pumice fall products; successively, grey pumice fall and pyroclastic flow and then PDC. The broken columns of the main atrium lie on the pumice fall deposits. The collapsing angle of the columns points out also the direction of the diluted currents (**Figure 18**). Around Somma-Vesuvius volcano, there is also a petrified tree that by its curvature shows the direction of the PDC. The first day of eruption produced 3 m of pyroclastic fall products blanket Pompeii, and some inhabitants fell asleep, and were buried by the collapse of their houses. Steps needed to obtain a mould of a body buried by pumice fall are: (1) the body was covered by pumice fall during the eruption; (2) organic matter was destroyed by heat, and the vacuum had been filled later on, in modern age, by gypsum; and (3) the shape of the body was then recovered (**Figure 19**).

6. The Somma-Vesuvius history after the AD 79 eruption

The history of ancient stratovolcano that suffered a caldera-like collapse, Somma [8, 10], ended with the AD 472 eruption. In Middle Ages, from AD 500 to AD 1100,

the mediaeval interplinian period occurred. During this period, the volcano alternates quiescence periods to effusive phases with low energy Strombolian style eruptions. The last reliable historical reports about this long time span concern the effusive activity that took place in 1139. The mediaeval interplinian activity was responsible



Figure 20.
Engraving showing Somma-Vesuvius during a repose period before the 1631 eruption.



Figure 21.
Portici marble label as the first action of Civil Protection at Somma-Vesuvius after the 1631 eruption.

for the construction of a new stratovolcano, the Vesuvio, which grew within the Somma caldera [14–19]. Since 1550, many coeval chronicles and the pictures of the Atlas by the cartographer Gerardus Mercator (1512–1594) make it possible to deduce that in this time span the Vesuvius was quiescent and that Gran Cono was covered by a closely cropping vegetation. On December 16, 1631, Vesuvius resumed its activity after 500 years of quiescence period. The eruption, with both effusive and explosive products, was not expected by the inhabitants, who were not aware that Vesuvius was an active volcano (**Figure 20**). Famous label was placed at Portici by Spanish viceroy after the AD 1631 eruption to warn the future generation about the volcanic risk of the Vesuvius (**Figure 21**). From 1631 to 1944, the last interplinian phase occurred. The typical volcanic activity, effusive and weak explosive, was developed according to a succession of volcanic cycle, called vesuvian cycle. Between the end of eighteenth century and the first half of the nineteenth century, in the absence of photographs,

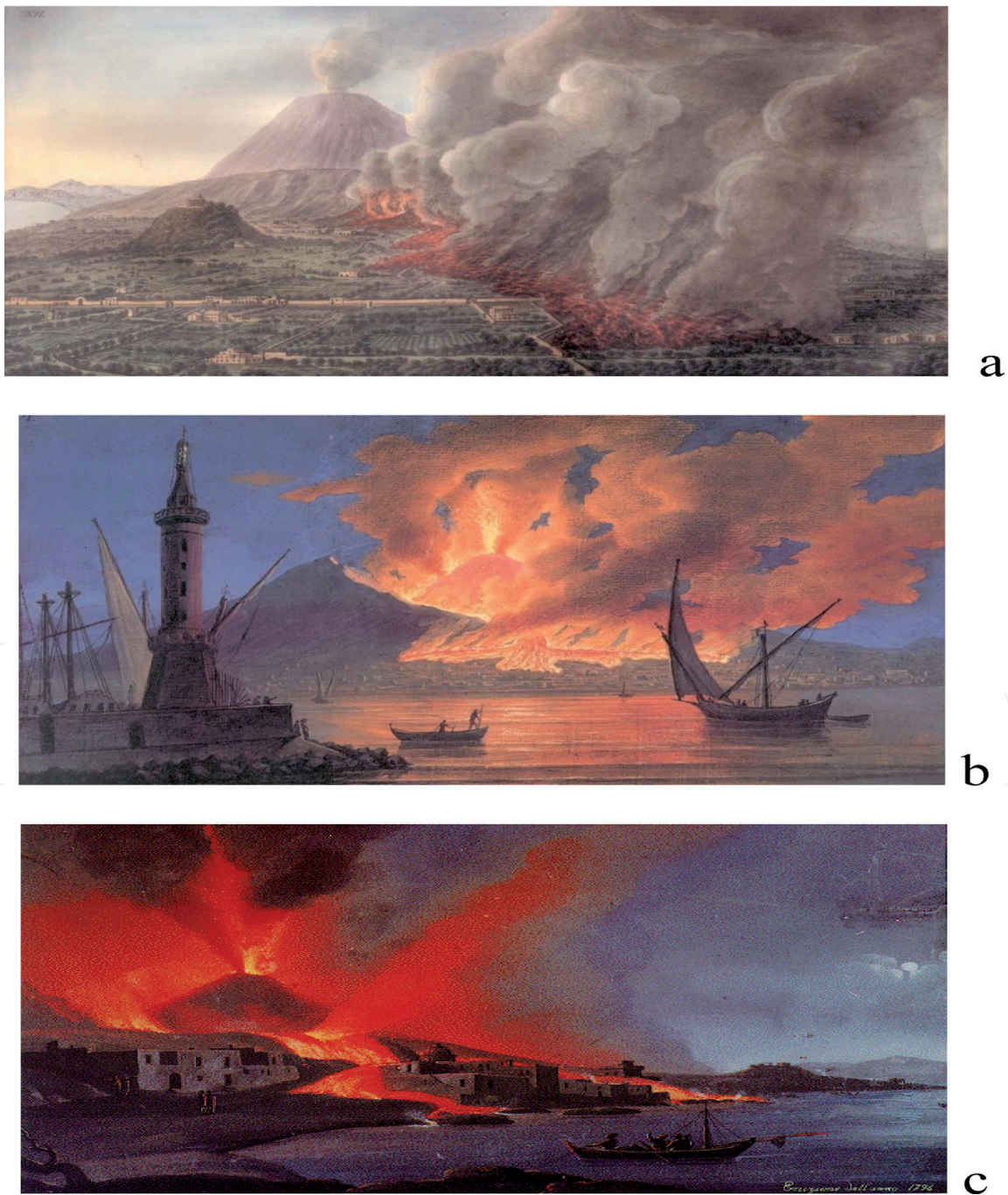


Figure 22.
(a) December 1760 eruption, Fabris. (b) October 20, 1767, Fabris (c) June 1794 eruption.

grew, in Napoli, painters “a la gouaches.” These artists represented the wonderful landscapes of the vesuvian area. Their pictures are the precious examples of the Neapolitan “vedutismo” (**Figure 22**).

A progressively increasing of both strombolian and effusive intracrateric activity preceded the 1822 paroxysm. In September, an appreciable seismic activity was recorded and also many springs of the vesuvian area dried up. After some volcanic eruptions, on October 20 and 21 during the night, finally the lava overflowed the crater rim and directed toward Resina (Ercolano) (**Figure 23**). In these years, on the southern flank of Vesuvius, above the Salvatore hill, the building of the first volcanological observatory of the world, the **Osservatorio Meteorologico Vesuviano**, was built. It was officially inaugurated on September 28, 1845, during the Conference of Italian Scientists held in Napoli.

This particular moment in history signaled for the people living there at a transition from a phase of fear of the volcano to one of lasting and increasing knowledge (**Figure 24**). The 1906 eruption was the paroxysmal phase of the Vesuvian cycle



Figure 23.
Interplinian eruption of 1822.

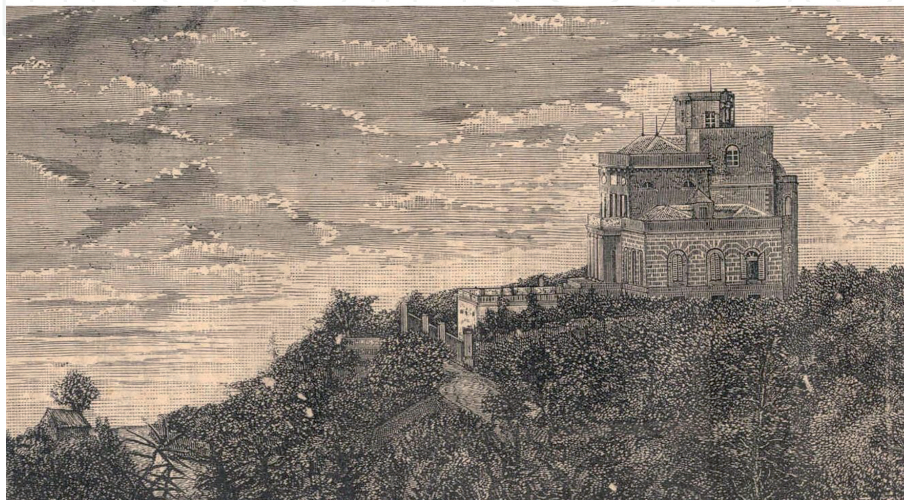


Figure 24.
Historical Vesuvian Observatory (first volcanological observatory on earth).

1874–1906. The eruption was observed and described by many Italian and foreign volcanologists. For the first time with 1906 eruption, Vesuvius photos were diffused in the scientific world also due to the contribution of newspapers and magazines (**Figure 25**). In 1913, the last Vesuvian cycle of the modern historic interplinian phase started, and on March 18, 1944, the paroxysmal eruption began (**Figure 26**). It was not long after the war that Italian people, especially those around Vesuvius, were busy sorting out other problems. The volcano eruption almost seemed like the lesser of two evils when compared to the destruction wrought by the Second World War in Campania. During the eruption, the Allied Force Command was involved in bringing an enormous help, through evacuation, to the population of Vesuvian municipalities and, in particular, of San Sebastino, which was firstly threatened and then invaded by lava flows (**Figure 27**). In 1944, Vesuvius entered a quiescence phase still now lasting, even if every now and then low magnitude seismic events,

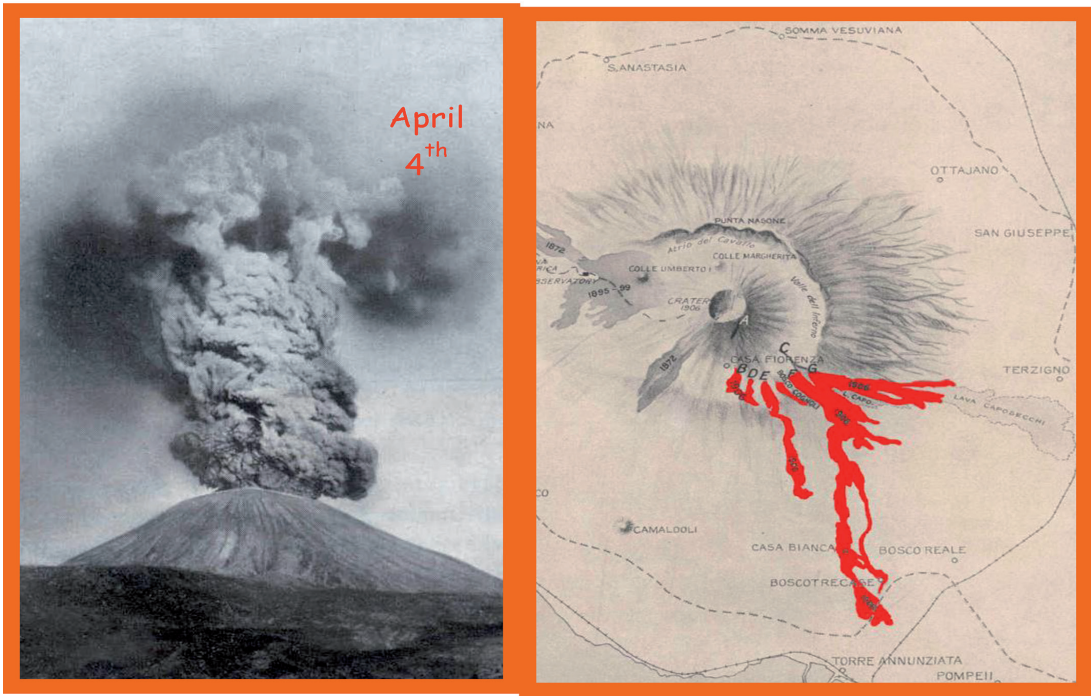


Figure 25.
1906 eruption: eruptive column and lava flow.

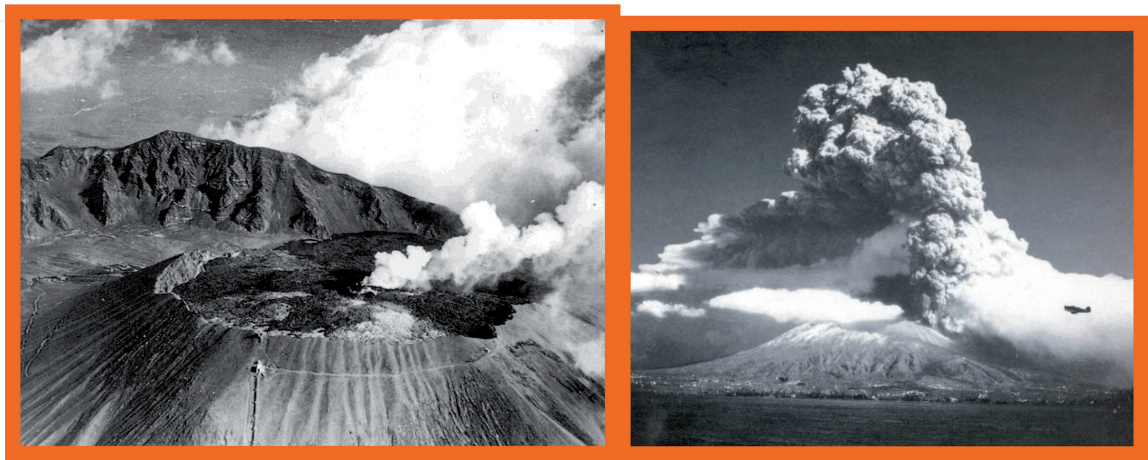


Figure 26.
1944 eruption: beginning of the eruption followed by a Vulcanian style eruption with an allied plane that suggest the height of the 1944 eruption column.



Figure 27.
1944 lava flow invaded the San Sebastiano al Vesuvio.



Figure 28.
Vesuvius crater after the 1944 explosive eruption.

together with a continuous fumarolic activity at the crater, remind people that, although dormant, the volcano is still active (**Figure 28**).

7. Estimating hazard and risk at Somma-Vesuvius

The last eruption at Vesuvius took place in 1944. After this date, the long lasting quiescence period encouraged the strong urbanization in perivolcanic areas. In the first decades of the twentieth century, when activity at Vesuvius was almost continuous, no significant increase in population rate was recorded along the Vesuvius coastline (**Figure 29**). In the last five decades, on the contrary, a very strong increase in population rate was recorded. In the coastal

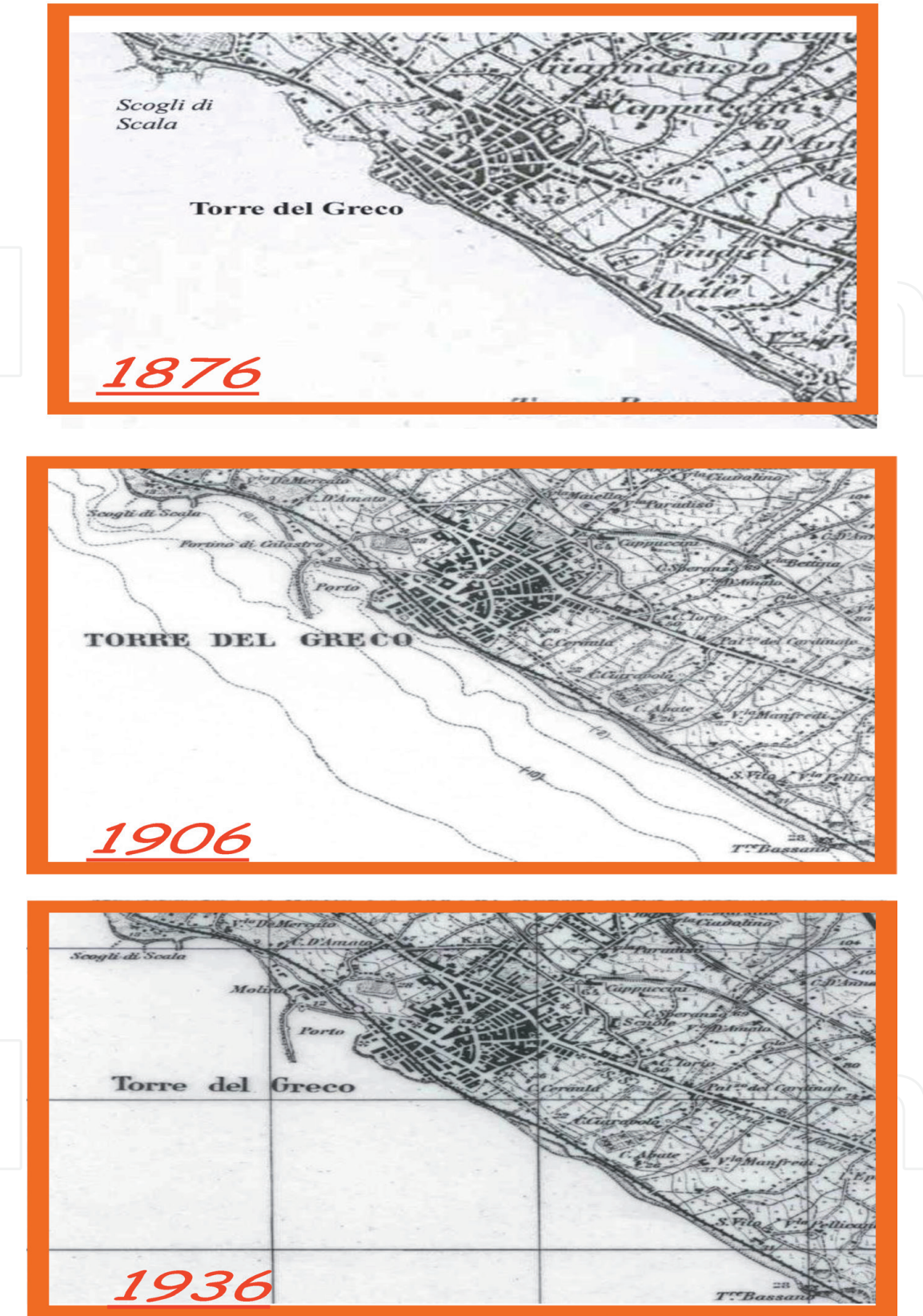


Figure 29.
Topographic maps of Torre del Greco by the following age: 1876, 1906, and 1936. This range does not represent an increase of the inhabitants. Data are taken from Italian newspapers.

area of Vesuvius, the population strongly increased up to 1980, when the large towns, already congested by traffic and degradation, become saturated (**Figure 30**). In 1930, inhabited areas were far from each other and located along the main municipal roads. In 1960, inhabited areas expanded and industrial sites grew in agricultural areas. At present, both inhabited and industrial

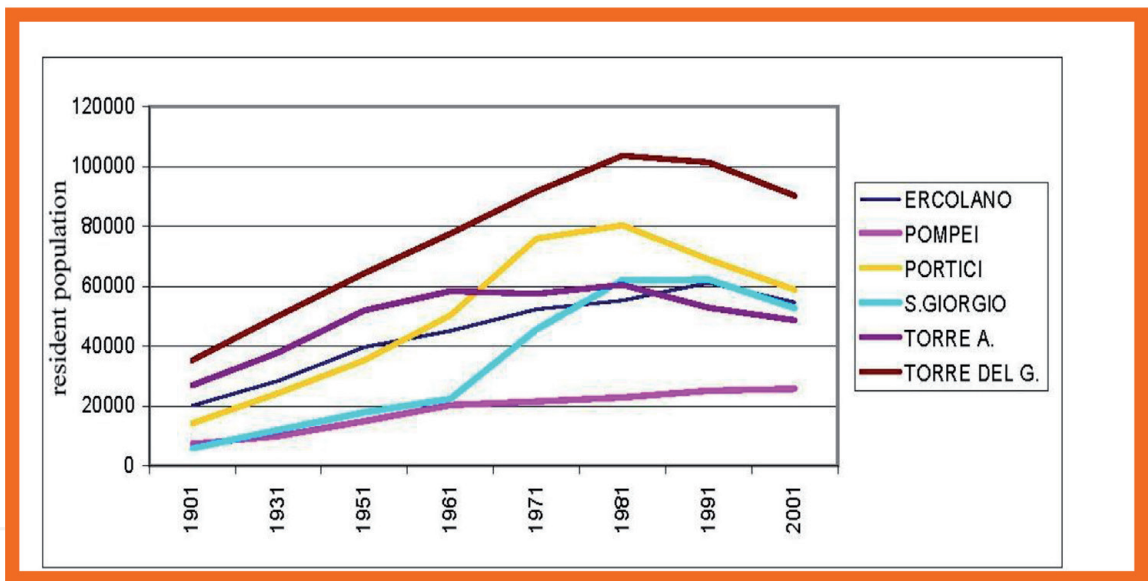


Figure 30. 1996 topographic map and a diagram pointing the increase of population in recent years (1996, unpublished data). From 1996 up to now, the increase of population has not stopped.

sites cover the whole territory, and agricultural areas are much reduced. A hazard map was obtained encompassing both the fall products possible hazard and the pyroclastic density current areas (drawn after Protezione Civile Italiana) (**Figure 31**).

8. Conclusion

The Somma-Vesuvius volcano is a composite stratovolcano with a complex history of caldera evolution. A sort of stratigraphic cyclicity is envisaged which suggests the style of the next eruption as Plinian. Anyhow, on the basis of size, it is very difficult to select an “ad-hoc” Plinian eruption which could be selected between Avellino, AD 79, AD 472, and AD 1631 eruptions. There is still a lot of

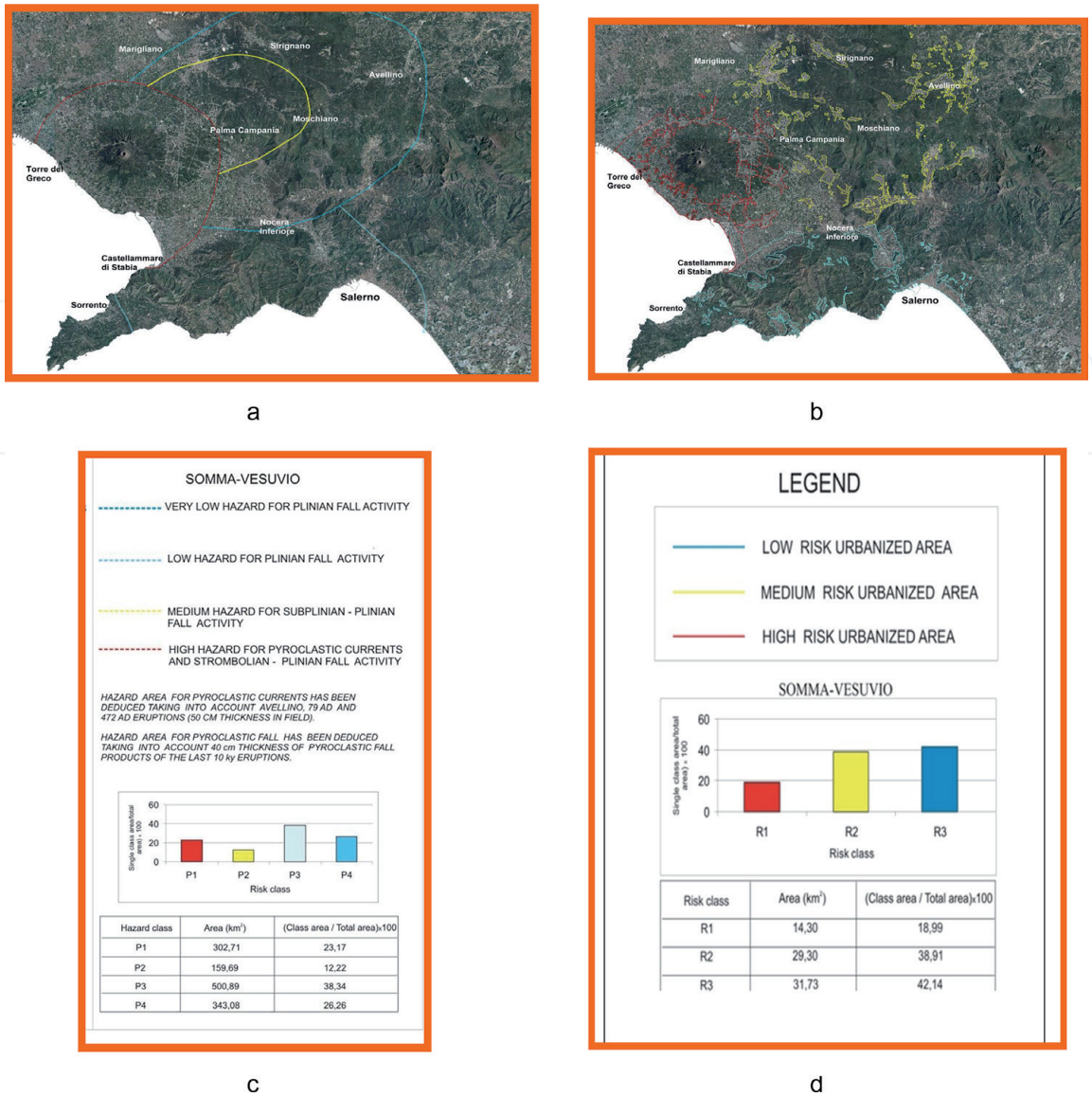


Figure 31.
Volcanic hazard and risk at Somma-Vesuvius.

confusion on this issue. Hazard and risk are very high due to the demographic increase around Vesuvius in the last 40 years (**Figure 30**). One of the last research [11] suggests that Napoli Municipality could be hit by a Plinian eruption so that hazard and risk would increase. From the volcano history, it can be noted that people have always forgotten the hazard and risk that Vesuvius pose. On the other hand, the Spanish have warned the population (1631 eruption) of the Hazard of Vesuvius Portici marble label (**Figure 21**). This protective action together with the construction of the Vesuvian Observatory indicates how Spanish were sensible about the behavior of the volcano. The AD 79 has been very well studied so that would be easy (cartoon model) for students understand the volcanic hazard. The volcanic section of the AD 79 drawn by Sigurdsson et al. [20] is still valid as a model to present how the AD 79 eruption has evolved and in parallel how Pliny the Younger wrote his letter.

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